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JC20 Rec'd PCT/PTO 15 APR 2005

RECOVERABLE ASSEMBLY AND METHOD OF ENCLOSING AN ELONGATED SUBSTRATE USING SUCH AN ASSEMBLY

This invention relates to a recoverable assembly and its method of use, for recovering a stretched sleeve onto a substrate.

Arrangements are known for holding an elastic, typically elastomeric, sleeve in a stretched condition after manufacture until it is required to be recovered in use onto a substrate. One example of such an assembly is disclosed in US-A-3515798 (Minnesota Mining and Manufacturing Company), in which an elastic tubular cover member is supported in a stretched condition on an easily removable one piece rigid helical core having interconnected adjacent coils. Uncoiling of the helix and removal of the core as a continuous narrow strip through the remainder of the helix permits the cover to be recovered onto a substrate disposed therewithin.

EP-A-0117092 (Minnesota Mining and Manufacturing Company) discloses a modification of US-A-3515798, in which the hollow tubular core for supporting the elastic tubular cover member comprises a cylindrical plastic tube having a plurality of circumferentially spaced, axially extending lugs on the inner wall of the tube and a continuous helical cut extending into the wall of the tube from the exterior surface thereof, severing the tube into a continuous narrow strip such that only the lugs are connected axially along the length of the tube.

US-A-5087492 (Societa Cavi Pirelli S.p.A.) discloses a stretched elastic sleeve that is mounted on a tubular supporting body formed by a helically wound tape with contiguous turns. The tape has transversely extending notches in the inner surface

thereof to improve the bendability of the tape. After the assembly of the sleeve and the body is disposed around a substrate, an electric cable joint, the tape is pulled out of the sleeve, permitting the sleeve to contract and to engage the cable.

US-A-5560969 (Pirelli Cavi S.p.A) discloses a further tubular supporting element for supporting an elastic sleeve, in which the wall of the element has a groove or incision directed along a helical line and which has a radial depth from the outer surface of the supporting element less than the radial thickness of the supporting element.

The stretched elastic sleeve-supporting member of each of the above-mentioned publications comprises a strip of material that is helically wound so as to form a tubular support member. In operation, the supported sleeve is positioned around the substrate to be covered, which may be a joint between electric cables, or a termination of such a cable, and one end of the strip is grasped and pulled back through the supporting member through the annular region between the supporting member and the substrate. As the strip is pulled out from within the elastic sleeve, the sleeve then recovers down onto the substrate. However, with such a hold-out assembly of the elastic sleeve, the operator has continually to pull the strip around the circumference of the substrate due to its helical winding within the sleeve. Furthermore, for a typical 400 mm length of the elastic tube, a strip length of the order of 10 meters has to be provided to form the rigid helical hold-out. It will be appreciated that the helical unwinding of the hold-out strip around the substrate for a length of about 10 meters, or even more, can be very inconvenient, particularly bearing in mind the inherent rigidity that is required for the material of the hold-out tape. Such helical hold-outs are usually manufactured as a linear strip that is then formed into a helical tube. It has been found that a significant

helical imprint remains on the inner surface of the elastic sleeve following withdrawal of the hold-out member. The development of such an imprint is exacerbated by the time that the elastic sleeve spends on the hold-out after it is pre-stretched and mounted thereon during manufacture, and stored prior to its release in use onto a substrate.

It is one object of the present invention to provide an assembly comprising a stretched elastic sleeve and a tubular hold-out member that overcomes, or at least alleviates the disadvantages with known assemblies.

In accordance with one aspect of the present invention, there is provided an assembly comprising an elastic sleeve mounted in a radially stretched condition on a tubular member that extends therebeyond at one end of the sleeve, wherein the tubular member includes a plurality of regions of weakness extending circumferentially therearound and discretely spaced apart along the length thereof.

Thus, in accordance with the present invention, a series of circumferential discrete regions of weakness allow the tubular hold-out member to remain in its tubular form as it is pulled back through itself. During this step, the hold-out member may be extended in length by a factor of 20% to 200% depending on design details, but this extension is significantly smaller than that obtained with existing helical hold-outs, so that the operator can conveniently pull the tubular member around the substrate so as to recover the sleeve thereonto. During the recovery process of the sleeve onto the substrate, the tubular member becomes stretched and has the form of a plurality of generally cylindrical rings interconnected by cylindrical hinges, thus generally retaining its tubular configuration throughout the recovery process.

Preferably the tubular member is of substantially right-cylindrical configuration, and the regions of weakness extend circumferentially substantially perpendicularly to the longitudinal axis thereof.

Advantageously, each region of weakness extends substantially continuously around the tubular member.

The regions of weakness may comprise indentations extending into the wall of the tubular member. Indentations may extend from the inner surface only, or from the outer surface only, or, preferably, from both surfaces. In the latter configuration, indentations from each surface may alternate along the length of the tubular member, and it is envisaged that a few, for example two, indentations from one surface, preferably the inner surface, may alternate with one indentation from the outer surface.

In an alternative configuration, the regions of weakness may be provided by the tubular member being of convoluted configuration.

The regions of weakness, for example indentations, or slits, may extend a different length longitudinally of the tubular member depending on whether they extend from the inner or from the outer surface. Advantageously, the inner regions of weakness are longer than the outer regions of weakness.

The regions of weakness may effectively divide the tubular hold-out member longitudinally, into a plurality of contiguous rings, the number of rings being dependent

on the length of the sleeve and thus of the tubular member. However, typically there may be more than fifty such rings, and as many as sixty or seventy for a sleeve of 400mm length.

The ratio of the depth of the regions of weakness transversely to the length of the tubular member to the separation of the regions of weakness longitudinally of the tubular member is at least 1:1, and may be 2:1, or more. However, it is also envisaged that this ratio may be as low as 1:3.

Whilst, in order to release the tubular member from inside the stretched sleeve when the assembly is disposed around an elongate substrate, the tubular member extends beyond the sleeve at at least one end thereof, it is preferable that the extension is at least equal to the length of the tubular member holding out the sleeve, so that the extension can be directed from the end back through the tubular member so as to allow it to be grasped beyond the other end of the tubular member thereby to facilitate inverting the tubular member and pulling it back through itself so as progressively to release the elastic sleeve down onto the substrate.

Advantageously the tubular member comprises a thermoplastic material or blends thereof, including cross linked thermoplastic material. Suitable materials are polypropylene (PP), polyethylene (PE), acrylonitrilebutadienestyrene (ABS), polypropylene/ethylenepropylenediene monomer (PP/EPDM) and cross-linked - polyethylene (V-PE).

The tubular hold-out member should, in general, be of such a configuration and constructed of such a material that allows its deformation and/or cracking to facilitate it being inverted and withdrawn back through itself. That is to say, it must be able to change from a state of being mechanically stable with regards to radial pressure, to one in which, whilst retaining a generally tubular shape, it can be inverted and reduce in diameter for withdrawal through itself; the regions of weakness allow this to occur. It will be appreciated, however, that the material of the tubular member has to be selected appropriately. Thus, the more rigid the material is, the thinner the wall thickness must be.

The tubular member may be formed by a moulding process, for example injection moulding or blow moulding, or by an extrusion process.

The elastic sleeve of the assembly is preferably made of an elastomer or rubber, preferably silicone or ethylenepropylenediene monomer (EPDM).

The sleeve may be provided as a single layer, or as two or more separate or integrated layers, which may or may not be co-terminous. In the latter case, different layers may have different mechanical and/or electrical properties as required to suit the substrate and the environment. One of the layers could, for example, be a mastic or a mesh, for example of metal.

In accordance with another aspect of the present invention, there is provided a method of enclosing an elongate substrate using an assembly according to any one of the preceding claims, wherein the assembly is positioned around the substrate with the

stretched sleeve longitudinally disposed over its final required position with the extension of the tubular member located invertedly in the annular region between the tubular member and the substrate, wherein, whilst maintaining the sleeve in its required position, the free end of the extension is pulled so as to invert the tubular member supporting the sleeve and to withdraw it through itself along the annular region until it is completely removed from the sleeve, thereby allowing the sleeve progressively to recover radially onto the substrate.

Although the present invention may be used to recover a suitable elastic sleeve onto any substrate as required, it does find particular advantage in electrical applications, where the sleeve can be recovered onto, for example, a splice between electrical cables, or over the termination of an electrical cable. To this end, the sleeve may be provided with electrical insulating, conductive, semi-conductive, or stress grading and/or weather resistant properties as required.

Embodiments of an assembly and its method of use, each in accordance with the present invention, will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic section through a first embodiment of an elastic sleeve mounted on a tubular hold-out member;

Figure 2 is an enlarged section of the region A of Figure 1;

Figure 3 shows a position in the application of the assembly of Figure 1 with the sleeve partially recovered onto a substrate;

Figure 4 is a detail of the region B of Figure 3;

Figure 5 is a section through a portion of a second embodiment of the tubular member of the assembly as moulded;

Figure 6 is a section corresponding to that of Figure 5 after the tubular member has been subjected to a longitudinal compression prior to mounting of the stretched sleeve thereon;

Figure 7 is a section through a portion of a third embodiment of the tubular member of the assembly as moulded;

Figure 8 is a section corresponding to that of Figure 7 alter the tubular member has been subjected to a longitudinal compression prior to mounting of the stretched sleeve thereon;

Figure 9 is a section through a fourth embodiment of the tubular member of the assembly as moulded;

Figure 10 is a schematic section through a portion of a fifth embodiment of the tubular member of the assembly as moulded;

Figure 11 is a schematic section through a portion of a sixth embodiment of the tubular member of the assembly as moulded;

Figure 12 is a schematic section through a portion of a seventh embodiment of the tubular member of the assembly as moulded;

Referring to Figures 1 to 4, an assembly comprises a cylindrical elastomeric sleeve 2 that is retained in a radially expanded configuration on a rigid right-cylindrical hold-out member 4. The hold-out member 4 comprises a first, outer portion 6 that supports the sleeve 2, and, contiguous therewith, an inner portion 8 that is folded back at one end of the sleeve 2, passes within the tubular member outer portion 6 and then emerges from the other end of the assembly.

As can be seen in Figure 2, the hold-out member 4 has rectangular slits extending thereinto at longitudinally spaced apart locations, with a first set of slits 10 extending from the inner surface and a second set of slits 12, alternating therewith, extending from the outer surface. The slits 10 and 12 extend continuously circumferentially around the tubular member 4 in planes that are substantially perpendicular to the longitudinal axis 14 of the assembly.

Referring specifically to Figures 3 and 4, the assembly is shown after it has been slid into position over a cylindrical substrate 16. As shown, the inverted free end 9 of the inner portion 8 of the hold-out member 4 is being pulled so as to bring about progressive inversion of the outer tubular portion 6, with the result that as the portion 6 is progressively withdrawn, the sleeve 2 recovers radially onto the surface of the substrate 16. Complete withdrawal of the hold-out member 4 in this way will result in the entire length of the sleeve 2 recovering into close conformity with the substrate 16.

Figure 4 shows how the inversion and withdrawal of the hold-out member 4 is facilitated by the presence of the circumferential slits 10 and 12, the arrows X indicating the direction of movement of the hold-out member, and the arrows Y indicating the direction of recovery of the sleeve 2.

Thus, as the inner tubular member portion 8 is pulled in the direction X it peels away from the sleeve 2, and the inner slits 10 allow the tubular member 4 to compress as it inverts, the inversion being facilitated by the outer slits 12 allowing the tubular member 4 to stretch upon inversion, with the slits 10 and 12 remaining stretched as the inner

portion 8 is then withdrawn through the annular region between the rigid portion of the member 4 and the substrate 16.

Figure 5 shows a section through the wall of a further embodiment of a tubular hold-out member 20 which has been formed in a mould so as to be of convoluted configuration with a set of generally U-shaped outer troughs 22 alternating with generally U-shaped inner troughs 24 to provide alternating inner and outer regions of weakness extending circumferentially around the tubular member 20.

Figure 6 shows the tubular member 20 after having been subject to a longitudinal compression so as substantially to close up the troughs 22 and 24 so as to provide a substantially smooth outer surface for the hold-out tubular member 20 for receiving a radially stretched elastomeric sleeve 2 thereon.

Figure 7 shows a section through the wall of a still further embodiment of a tubular hold-out member 30 which has been formed in a mould so as to be of convoluted configuration with a set of outer troughs 32 alternating with inner troughs 34 to provide inner and outer regions of weakness extending circumferentially around the tubular member 30. In this embodiment, the innermost and outermost walls of the tubular member 30 are relatively thick and are interconnected by relatively thin, and thus more flexible, side portions 36.

Figure 8 shows the tubular member 30 after having been subject to a longitudinal compression so as substantially to close up the troughs 32 and 34 so as to provide a

substantially smooth outer surface for the hold-out tubular member 30 for receiving a radially stretched elastomeric sleeve 2 thereon.

Figure 9 shows another embodiment of tubular member 37 of convoluted configuration with the inner space regions 38 being wider than the outer space regions 39. Whether longitudinal compression of the embodiments of Figures 5, 7 and 9 is necessary, and to what extent, will depend on the material of the hold-out member and on the material of the elastic sleeve, especially on the hardness thereof. Thus, the harder a material is selected for the sleeve, the less likely it is to deform into the openings at the outside of the hold-out member, and the greater the length of the openings longitudinally of the member can be. In the case of a multi-layer sleeve, its inner or innermost layer may be of a harder material than outer layer(s). In this way, deformation into the regions of weakness of the hold-out member can be avoided, or at least minimised, whilst still providing sufficient radially-inwards pressure to ensure full recovery onto a substrate.

Referring to Figure 10, a tubular hold-out member 40 is shown schematically with relatively narrow slits 42 formed in its outer surface, and alternating therewith, relatively wide slits 44 in its inner surface. This represents the preferred general configuration of the tubular member of the assembly of the invention. Also, this figure shows by way of example a ratio of the wall thickness H of the tubular member to the longitudinal length W of the sections thereof between successive regions of weakness of approximately 2:1.

In the embodiment of tubular hold-out member 50 shown schematically in Figure 11, slits 52 are shown provided only in the outer surface thereof. Also this shows that the ratio of the wall thickness H to the "ring" width W is approximately 1:1.

In a further embodiment of tubular member 60 shown schematically in Figure 12, slits 62 in the outer surface thereof are relatively short, compared with the slits 52 of the tube 50 (Figure 11) whilst being spaced apart at substantially the same distance, giving a ratio of the wall thickness H to the longitudinal extension W of the ring element of 1:3, for example.

It will be appreciated that each embodiment of hold-out member shown in Figures 10, 11 and 12 present a substantially - smooth outer surface for receiving the elastomeric sleeve.